

EU KLEMS Growth and Productivity Accounts 2016 Release, Statistical Module¹

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Introduction

This document describes a new set of [EU KLEMS Productivity and Growth Accounts](#) with data up to 2014 for 10 major European economies (Austria, Belgium, Germany, Finland, France, Italy, Netherlands, Spain, Sweden, and United Kingdom).

This release is the first of two, which have been carried out with funding from the [European Commission, DG for Economic and Financial Affairs](#). While the current data are limited to 10 major economies, that were also part of previous intermediate updates, the next update in 2017 will include a wider range of economies as well as the Japan and the United States. The 2016 EU KLEMS release follows up on earlier rolling releases in 2012 which showed detailed growth accounts up to 2009-2012 depending on the country.

The 2016 EU KLEMS database keeps the general standard EU KLEMS structure of previous round, where variables are broken down into values, prices, volumes, and additional variables. For more detailed information on the general growth accounting methodology and construction of the database, see O'Mahony and Timmer (2009). One important difference between this release and previous ones, is that the measures of capital services in this version are based on the official stock data from National Statistical Institutes (NSIs) and additional computations to turn them into capital services measures. While this adjustment is somewhat affecting the comparability of the series across countries, the results in this release are more in line with the official national accounts estimates of underlying variables. Hence we refer to this release as a "statistical module" of EU KLEMS, which are therefore not directly comparable to the "analytical module" as developed before.

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For the next release in summer 2017, we envisage the publication of both a statistical and an analytical module of the EU KLEMS database.

The 2016 release has a number of features worth noting, which are explained in this document in more detail:

- Concepts and methodologies to calculate the various growth and productivity variables were adjusted to the new European System of National Accounts (ESA 2010).
- The time period coverage is 1995-2014 for most countries and industries.
- The data on output, value added and employment is nearly fully consistent with Eurostat at the corresponding industry levels - if not mentioned otherwise in the country notes below.
- The data on gross fixed capital formation, prices, and capital stocks is consistent with Eurostat at the corresponding industry levels - if not mentioned otherwise in the country notes below.
- The capital asset types were modified and extended according to the ESA 2010 requirements.
- One important deviation from previous EU KLEMS releases is that capital stock figures are mostly obtained from Eurostat, and are thus consistent with national accounts assumptions on the measurement of capital stock - if not mentioned otherwise in the country notes below.
- Capital services, an essential part of EU KLEMS database, are not part of the official System of National Accounts which necessitates assumptions regarding depreciation rates and the calculation of the rates of return. As implicit depreciation rates from official data were often highly volatile, we systematically applied geometric depreciation rates, as in previous EU KLEMS versions. Therefore the measures of capital stock are not fully consistent with our measures of rates of return, rental prices and consequently capital services. We keep a detailed analysis of this data for later revisions.
- For constructing labour services for the period 2008-2014, the micro-data underlying the European Labour Force Survey (LFS) has been used through the National Institute of Economic and Social Research (NIESR). Years prior 2008 have been extrapolated using the trend in labor services from former versions of EU KLEMS.

Table A1 in the appendix lists all variables of the output and capital files, broken down into values, prices, volumes, and additional variables. The content of the basic and capital files will be extended for the 2017 release. Variables will be available to the extent possible as laid out in table A1 in O'Mahony and Timmer (2009) which largely correspond to the set of variables published in the first full release of the EUKLEMS database in March 2008. A novelty of the 2016 release is the provision of three-dimensional growth accounts across countries and industries where possible (see table 1). The 2016 release provides contributions to growth rates of value added and labor productivity, with the latter measured in two ways – value added per hour worked and value added per person employed. The full KLEMS approach, using gross output and all five major input factors (K-L-E-M-S) will also be available with the 2017 release. However, in several cases (depending on country and time period) we will have to reside with the narrower concepts (K-L-E) even in the 2017 release.

Table 1: Growth accounting approaches of the EU KLEMS release

EU KLEMS Approaches: Contributions to...		
1) LP2: Value Added / Person Employed	VA/EMP	Minimum approach
2) LP1: Value Added / Hour worked	VA/H_EMP	↕
3) Value Added and KL Inputs	VA	
4) Gross Output and KLEMS Inputs (2017 release)	GO	Maximum approach

The remainder of this document details the structure of the 2016 EU KLEMS database and general methods applied to this release to arrive at estimates of total factor productivity in the NACE 2 industry classification and the new European System of National Accounts (ESA 2010). Main differences between the former EU KLEMS releases and this release are briefly highlighted. Additionally, this section covers the methods applied for the calculation of labour services.

Industry Classification

European National Statistical Institutes (NSIs) produce data based on the NACE 2 industry classification, which is consistent with the international standardized ISIC Revision 4 industry classification. The industry structure known from the 2012 EU KLEMS release is adopted with the market economy as an addition. We distinguish between 34 industries plus 8 aggregates as shown in table 2. The NACE 2 output and labour data used in this release are based on Eurostat insofar available. The National Accounts (NA) data in the new European System of National Accounts (ESA 2010) is provided for shorter time series than were previously available under ESA 1995. Earlier releases of the EU KLEMS databases provide time series back to 1970 with estimations of Total Factor Productivity (TFP) generally starting in 1980. Back-casts of the time series of output and labour data back to 1970 will be made for the 2017 release of the project through linkages to former EU KLEMS files to the extent possible.

Table 2: EU KLEMS industries

34 industry list, based on NACE Rev.2 / ISIC Rev. 4		
No	Description	Code
Agg	TOTAL INDUSTRIES	TOT
Agg	MARKET ECONOMY	MARKT
1	AGRICULTURE, FORESTRY AND FISHING	A
2	MINING AND QUARRYING	B
Agg	TOTAL MANUFACTURING	C
3	Food products, beverages and tobacco	10-12
4	Textiles, wearing apparel, leather and related products	13-15
5	Wood and paper products; printing and reproduction of recorded media	16-18
6	Coke and refined petroleum products	19
7	Chemicals and chemical products	20-21
8	Rubber and plastics products, and other non-metallic mineral products	22-23
9	Basic metals and fabricated metal products, except machinery and equipment	24-25
10	Electrical and optical equipment	26-27
11	Machinery and equipment n.e.c.	28
12	Transport equipment	29-30
13	Other manufacturing; repair and installation of machinery and equipment	31-33
14	ELECTRICITY, GAS AND WATER SUPPLY	D-E
15	CONSTRUCTION	F
Agg	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	G
16	Wholesale and retail trade and repair of motor vehicles and motorcycles	45
17	Wholesale trade, except of motor vehicles and motorcycles	46
18	Retail trade, except of motor vehicles and motorcycles	47
Agg	TRANSPORTATION AND STORAGE	H
19	Transport and storage	49-52
20	Postal and courier activities	53
21	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	I
Agg	INFORMATION AND COMMUNICATION	J
22	Publishing, audiovisual and broadcasting activities	58-60
23	Telecommunications	61
24	IT and other information services	62-63
25	FINANCIAL AND INSURANCE ACTIVITIES	K
26	REAL ESTATE ACTIVITIES	L
27	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	M-N
Agg	COMMUNITY SOCIAL AND PERSONAL SERVICES	O-U
28	Public administration and defence; compulsory social security	O
29	Education	P
30	Health and social work	Q
Agg	ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES	R-S
31	Arts, entertainment and recreation	R
32	Other service activities	S
33	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	T
34	Activities of extraterritorial organizations and bodies	U

Aggregation

Not all industries and aggregates shown in table 2 are readily available from Eurostat and several aggregates are calculated (table 3). NACE 2 industries are aggregated by simple summation for nominal variables. Tornqvist aggregates are estimated from the corresponding child NACE 2 industries, using the corresponding nominal variable as weights. All growth accounting related variables, namely growth rate of value added volume (VA_Q), growth rate of value added per hour worked (LP1_Q), growth rate of value added per person employed (LP2_Q), their growth contributions, and TFP indexes exclude industries T and U from the aggregates total economy, and O-U because capital stocks and GFCF are usually not available. Some series may not sum exactly to totals due to rounding, but any differences are well within the uncertainty of the estimates.

Table 3: EU KLEMS aggregates

Code	Description
TOT	TOTAL INDUSTRIES
MARKT	MARKET ECONOMY
20-21	Chemicals and chemical products
26-27	Electrical and optical equipment
D-E	ELECTRICITY, GAS AND WATER SUPPLY
49-52	Transport and storage
O-U	COMMUNITY SOCIAL AND PERSONAL SERVICES
R-S	ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES

Table 4 summarizes the industry coverage of the market economy and the total economy. The market economy covers total industries minus L, O, P, Q, T, and U for all variables of the output files and capital files. Growth accounting related variables additionally exclude industries T and U from the total economy, because capital stocks and GFCF are usually not available for industries T and U.

Table 4: Definition of the total economy and the market economy

	Growth accounting variables*	All other variables
Total Economy	All industries excluding T and U	All industries including T and U
Market Economy	All industries excluding L, O, P, Q, T, and U	All industries excluding L, O, P, Q, T, and U

Note: * LAB_QI, CAP_QI, VA_Q, LP1_Q, LP2_Q, their growth contributions, and TFP indexes

Output

Eurostat is rounding chain linked volumes of gross value added volume (2010=100) as well as the percentage change over previous period to only one decimal place for some countries. Volumes of gross value added (VA_QI) are therefore denoted in 2010 prices instead of an index where 2010 is set to 100, to keep the detail needed for the growth accounting exercise and other research tasks. The growth rate of value added volume (VA_Q) in the output files has been calculated based on volumes of gross value added in 2010 prices because Eurostat is also rounding VA_Q to only decimal place and we refrain from decomposing rounded VA growth in the growth accounting exercise. The recalculated growth rates of value added volumes VA_Q may therefore differ slightly from the official VA_Q figures from Eurostat.

Asset types

Changes in the asset boundary under ESA 2010 do not only affect important figures throughout the national accounts, they also require a revision to the structure of the non-financial assets classification in EU KLEMS. More assets are included in the definition of Gross Fixed Capital Formation (GFCF) in ESA 2010. In addition to the inclusion of new asset types, existing assets have been redefined, re-organised and re-numbered in the nomenclature.

The main changes of ESA 2010 that are relevant for EU KLEMS can be summarised as follows (Eurostat, 2014):

- Intangible assets were recognized as produced fixed assets (AN.112) and non-produced fixed assets (AN.22) in ESA 95². The produced fixed assets come under the new heading of

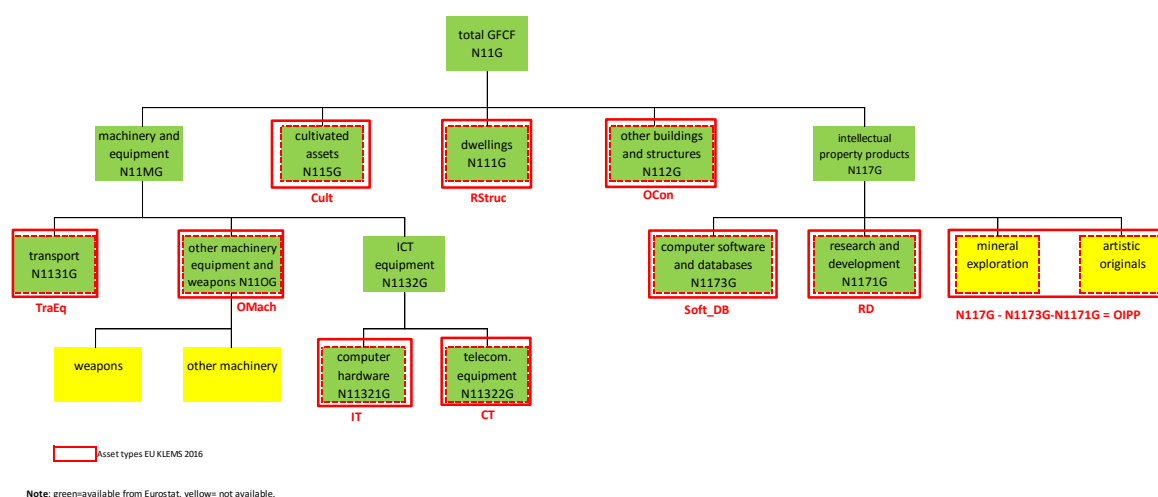
² Mineral exploration (AN.1121), computer software (AN.1122), entertainment, literary and artistic originals (AN.1123), and other intangible fixed assets (AN.1129) were recognized as (produced) intangible fixed assets in ESA95. Patented entities (AN.221) were part of non-produced intangible assets in ESA95.

intellectual products in ESA 2010. The asset boundary under ESA 2010 was further expanded by including research and development as intellectual property under the heading of produced assets.

- Computer software has been modified to include databases, where software and databases are treated as two subcomponents.
- Only the acquisition of military structures and equipment that were considered to have a civilian purpose were recorded as capital formation under ESA 95. The boundary of military capital assets has been extended to include military weapons and supporting systems that do not have an equivalent civilian purpose. Weapons systems are classified separately and are recognized as produced assets under machinery and equipment.

Figure 1 shows the new structure of the asset boundary under ESA 2010 and also indicates the current availability in the national accounts section on the Eurostat webpage.

Figure 1: Availability of gross fixed capital formation by assets, based on ESA 2010



For the purpose of the 2016 EU KLEMS release, we break total capital into ten asset types and label them as follows:

Table 5: EU KLEMS asset types, based on ESA 2010.

Code	NA Asset Name	EU KLEMS Asset Name	Short
N111G	Dwellings	Residential structures	RStruc
N112G	Other buildings and structures	Total non-residential investment	OCon
N1131G	Transport equipment	Transport equipment	TraEq
N11321G	Computer hardware	Computing equipment	IT
N11322G	Telecommunications equipment	Communications equipment	CT
N110G	Other machinery and equipment and weapons systems	Other machinery and equipment and weapon systems	OMach
N115G	Cultivated biological resources	Cultivated assets	Cult
N117G - N1173G- N1171G	Intellectual property products	Other Intellectual Property Products	OIPP
N1171G	Research and development	Research and development	RD
N1173G	Computer software and databases	Computer software and databases	Soft_DB

The new structure of asset types has also implications for the well-known standard grouping of asset types in EU KLEMS into non-ICT and ICT. In previous versions, ICT capital was classified in three

categories, namely computing equipment (IT), communication equipment (CT) and software. The changes in the current EU KLEMS update are as follows:

- Computer hardware which is equal to computing equipment (IT) and telecommunications equipment (CT) together equal ICT equipment and the series are comparable to what has been available under ESA 95.
- Computer software now includes databases and is therefore not entirely comparable to what was measured as software in the previous EU KLEMS datasets.
- In addition, computer software and databases are a subcomponent of intellectual property products, besides research and development and other IPP (OIPP) consisting of mineral exploration, and artistic originals (formerly known as other assets). Other IPP is not readily available from Eurostat and has therefore been calculated by deducting computer software and databases N1173G and research and development N1171G from intellectual property products N117G.
- Investment in cultivated assets accounts for only a minor share in total GFCF as they almost exclusively occurred in section A (agriculture, forestry and fishing). These were part of 'other assets' in former EU KLEMS and are treated as separate asset type in the 2016 release to keep as much detail as possible.

Investment series and capital services

Gross fixed capital formation by industry and asset type is mainly obtained from Eurostat for the EU KLEMS 2016 release. Data from NSIs are used to fill in gaps if any. In most cases, there are no revised ESA 2010 estimates available from Eurostat or NSIs before 1995 which explains why all growth accounting related variables are not available earlier for most countries.

The main difference of this release compared to former EU KLEMS releases concerns capital stocks. EU KLEMS time series of capital stocks prior to this 2016 release were calculated based on an analytical module applying the standard PIM with assumed geometric depreciation rates. Initial capital stocks were estimated based on capital stocks to value added ratios from the output and capital input files, in a country dependent initial year, usually 1970. The current release deviates from this previous practice and follows a statistical module where capital stocks by industry and asset type are taken directly from Eurostat to ensure that most official data are applied. The PIM is also the preferred method of the national statistical offices from those countries that are covered in the 2016 release, with Belgium being an exemption from the standard practice.

Volumes of investment and capital stocks in the current version are denoted in 2010 prices instead of an index where 2010 is set to 100, since 2010 investment and stocks are zero in some cases.

ICT investment in the previous versions of EU KLEMS were deflated using hedonic price deflators, based on U.S. constant quality price changes. However, in the current version, we rely on official ICT prices, which are assumed to reflect quality adjusted price declines. Recent evidence, however, suggests that the official deflators underestimate the true price decline in even in the United States (Byrne and Corrado, 2016). Alternative price measures developed by Byrne and Corrado (2016) have been used in the Conference Board Total Economy Database (TED), but for the aggregate economy only.

Capital compensation (CAP) is derived using the standard EU KLEMS approach where CAP equals value added minus labour compensation (LAB). LAB is calculated by applying the ratio of hours

worked by total persons engaged to hours worked by employees to compensation; assuming the self-employed receive the same hourly wages as employees.

Capital services, an essential part of EU KLEMS database, are not part of the official System of National Accounts. Measurement of capital services requires data on capital stock and rental prices³, which necessitates assumptions regarding depreciation rates and the calculation of the rates of return. Capital services (CAP_QI) are calculated based on geometric depreciation rates by asset and industry largely obtained from previous EU KLEMS versions. Depreciation rates for computing equipment, communications equipment, software and databases, transport equipment, other machinery, total non-residential investment, other IPP (formerly known as other assets) are taken from former EU KLEMS releases. The depreciation rate for cultivated assets stems from Montinari et al. (2016) and the depreciation rate for research and development is taken from the SPINTAN project. However, as our capital stock estimates are taken from official data, this assumption create some internal inconsistencies – the depreciation rates assumed by the NSA's could be different from the depreciation rates we use in our calculations and therefore, the measures of capital stock are not fully consistent with our measures of rates of return, rental prices and consequently capital services.

To address this issue, we tried using the implicit depreciation rates from official data. As the NSIs mostly apply the standard PIM, we also calculated implicit depreciation rates based on investment series and capital stocks in volumes. While those implicit depreciation rates are generally close to the standard EU KLEMS depreciation rates, they often fluctuate substantially from one year or industry to another and sometimes even turn negative. Hence we decided to use extended standard EU KLEMS depreciation rates for all countries to calculate capital services.

Labour service

In order to construct the labour service indices we draw on a number of micro-data sources. Information on the employment structure of the workforce is derived from the European Labour Force Survey (EULFS). We extracted total numbers of people employed for each of the EU-28 countries on an industry basis (19 industries, in the NACE Rev. 2 Classification). We do this on an annual basis; by computing the averages of total people employed from the EULFS quarterly files, currently available up to 2014 (the averages are weighted up using population weights).

In addition to the country and economic activity dimensions, we split the number of people employed according to a number of demographic characteristics. We distinguish a total of eighteen demographic groups within each country, industry and year cell. We consider two gender categories (male, female), three age categories (15-29 years; 30-49 years; 50 years and higher) and three educational qualifications levels (high, medium and low⁴). A potential drawback of using such a detailed split is the insufficient information on employment in some of the categories. This is likely to be more problematic for smaller industries in smaller countries, where there was no data or the sample sizes were low. In these cases, we assess the plausibility of the estimates by applying interpolation techniques using growth in employment in other relevant groups. Obviously the lack of information can affect the accuracy of some of the estimates. A similar methodology to the one

³ We constrain the rental price to be non-negative, setting it to zero in rare case where it is negative.

⁴ High qualification comprise those with a university degree and above (ISCED 5 and 6); Medium qualification comprise those with upper secondary and post-secondary non-tertiary education (ISCED 3 and 4); Low qualification comprise those with lower secondary (compulsory education) and below (ISCED<3).

described above was used to extract information on average (actual) hours worked, but in this case only the educational attainment split was considered.

The second key information required in the calculation of labour services is wages. These are mainly drawn from the Structure of Earning Survey (SES), which contains information on wage structure for the EU countries in three years: 2002, 2006 and 2010. We extracted average gross hourly wages for an equivalent breakdown to the employment figures. Information is available for all EU countries in the current set of countries. Unpublished data were acquired for the Austrian SES for 2002 and 2006. With regards to the industry coverage, the SES does not cover the agriculture, forestry and fishing and mining and quarrying industries. Information from the SILC (Survey of Income and Living Conditions) survey was used to update to 2014 and for countries/industries not covered by SES or national sources. Given the much smaller sample size in SILC, the updates were based on growth rates for only three broad industry groups, production industries, market services and non-market services.

Both ingredients for labor services (hours worked and wages) are calculated for the period 2008 to 2014 as described above. We applied the growth rate of labour service from EU KLEMS 2012 for the period prior to 2009. Labor quality is not calculated directly but falls out as the difference between the changes in labor services less the changes in hours worked.

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Appendix

Table A1: Variables of the EU KLEMS 2016 release.

Basic File	
Values	
VA	Gross value added at current basic prices (in millions of national currency)
GO	Gross Output at current basic prices (in millions of national currency)
II	Intermediate inputs at current purchasers prices (in millions of national currency)
COMP	Compensation of employees (in millions of national currency)
EMP	Number of persons engaged (thousands)
EMPE	Number of employees (thousands)
H_EMP	Total hours worked by persons engaged (thousands)
H_EMPE	Total hours worked by employees (thousands)
Prices	
VA_P	Gross value added, price indices, 2010 = 100
GO_P*	Gross output, price indices, 2010 = 100
II_P*	Intermediate inputs, price indices, 2010 = 100
Volumes	
VA_QI	Gross value added, volume (2010 prices)
GO_QI*	Gross output, volume (2010 prices)
II_QI*	Intermediate inputs, volume (2010 prices)
LP_I	Gross value added per hour worked, volume indices, 2010 = 100
Growth accounting	
LAB	Labour compensation (in millions of national currency)
CAP	Capital compensation (in millions of national currency)
LAB_QI	Labour services, volume indices, 2010 = 100
CAP_QI	Capital services, volume indices, 2010 = 100
Contributions to value added growth	
VA_Q	Growth rate of value added volume (% per year)
VAConH	Contribution of hours worked to value added growth (percentage points)
VAConLC	Contribution of labour composition change to value added growth (percentage points)
VAConKIT	Contribution of ICT capital services to value added growth (percentage points)
VAConKNIT	Contribution of non-ICT capital services to value added growth (percentage points)
VAConTFP	Contribution of TFP to value added growth (percentage points)
TFPva_I	TFP (value added based) growth, 2010 = 100
Contributions to value added per hour worked growth	
LP1_Q	Growth rate of value added per hour worked (% per year)
LP1ConLC	Contribution of labour composition change to value added per hour worked growth (percentage points)
LP1ConKIT	Contribution of ICT capital services to value added per hour worked (percentage points)
LP1ConKNIT	Contribution of non-ICT capital services to value added per hour worked (percentage points)
LP1ConTFP	Contribution of TFP to value added per hour worked growth (percentage points)
TFPp1_I	TFP (value added per hour worked based) growth, 2010=100
Contributions to value added per person employed growth	
LP2_Q	Growth rate of value added per person employed (% per year)
LP2ConLC	Contribution of labour composition change to value added per person employed growth (percentage points)
LP2ConKIT	Contribution of ICT capital services to value added per person employed (percentage points)
LP2ConKNIT	Contribution of non-ICT capital services to value added per person employed (percentage points)
LP2ConTFP	Contribution of TFP to value added per person employed growth (percentage points)
TFPp2_I	TFP (value added per person employed based) growth, 2010=100

Capital Input File

Nominal gross fixed capital formation, in millions of national currency

I_IT	Computing equipment
I_CT	Communications equipment
I_Soft_DB	Computer software and databases
I_TraEq	Transport Equipment
I_OMach	Other Machinery and Equipment
I_OCon	Total Non-residential investment
I_RStruc	Residential structures
I_Cult	Cultivated assets
I_RD	Research and development
I_OIPP	Other IPP assets
I_GFCF	All assets

Real gross fixed capital formation volume (2010 prices)

Iq_IT	Computing equipment
Iq_CT	Communications equipment
Iq_Soft_DB	Computer software and databases
Iq_TraEq	Transport Equipment
Iq_OMach	Other Machinery and Equipment
Iq_OCon	Total Non-residential investment
Iq_RStruc	Residential structures
Iq_Cult	Cultivated assets
Iq_RD	Research and development
Iq_OIPP	Other IPP assets
Iq_GFCF	All assets

Gross fixed capital formation price index (2010=100.0)

Ip_IT	Computing equipment
Ip_CT	Communications equipment
Ip_Soft_DB	Computer software and databases
Ip_TraEq	Transport Equipment
Ip_OMach	Other Machinery and Equipment
Ip_OCon	Total Non-residential investment
Ip_RStruc	Residential structures
Ip_Cult	Cultivated assets
Ip_RD	Research and development
Ip_OIPP	Other IPP assets
Ip_GFCF	All assets

Nominal capital stock, in millions of national currency

K_IT	Computing equipment
K_CT	Communications equipment
K_Soft_DB	Computer software and databases
K_TraEq	Transport Equipment
K_OMach	Other Machinery and Equipment
K_OCon	Total Non-residential investment
K_RStruc	Residential structures
K_Cult	Cultivated assets
K_RD	Research and development
K_OIPP	Other IPP assets
K_GFCF	All assets

Real fixed capital stock (2010 prices)

Kq_IT	Computing equipment
Kq_CT	Communications equipment
Kq_Soft_DB	Computer software and databases
Kq_TraEq	Transport Equipment
Kq_OMach	Other Machinery and Equipment
Kq_OCon	Total Non-residential investment
Kq_RStruc	Residential structures
Kq_Cult	Cultivated assets
Kq_RD	Research and development
Kq_OIPP	Other IPP assets
Kq_GFCF	All assets

Additional variables

Deprate	EU KLEMS Geometric depreciation rates
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Note: *Only Finland, Netherlands, and Sweden.